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Six Office of National Marine Sanctuaries (ONMS) Conservation Science reports





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HIGHLIGHTED ARTICLES

Enhancing the TurtleWatch product for leatherback sea turtles, a dynamic habitat model for ecosystem-based management

Fisheries Oceanography (2.542)

E. A. Howell (NMFS/PIFSC), **A. Hoover**, **S. R. Benson** (NMFS/SWFSC), **H. Bailey**, **J. J. Polovina** (NMFS/PIFSC), **J. A. Seminoff** (NMFS/SWFSC), and **P. H. Dutton** (NMFS/SWFSC)

- The expanded NOAA TurtleWatch product provides information on loggerhead and leatherback habitat and can be used by managers and industry to make dynamic management decisions to potentially reduce incidentally capturing turtles during fishing operations.
- The updated TurtleWatch provides for management of the Hawaii-based shallow-set fishery to aid in the bycatch reduction of sea turtles.

Fishery management measures to reduce interactions between fisheries and endangered or threatened species have typically relied on static time-area closures. While these efforts have reduced interactions, they can be costly and inefficient for managing highly migratory species such as sea turtles. The NOAA TurtleWatch product was created in 2006 as a tool to reduce the rates of interactions of loggerhead sea turtles with shallow-set longline gear deployed by the Hawaii-based pelagic longline fishery targeting swordfish. TurtleWatch provides information on loggerhead habitat and can be used by managers and industry to make dynamic management decisions to potentially reduce incidentally capturing turtles during fishing operations.

TurtleWatch is expanded here to include information on endangered leatherback turtles to help reduce incidental capture rates in the central North Pacific. Fishery-dependent data was combined with fishing effort, bycatch, and satellite tracking data of leatherbacks to characterize sea surface temperature (SST) relationships that identify habitat or interaction “hotspots”.

Analysis of SST identified two zones, centered at 17.2°C and 22.9°C, occupied by leatherbacks on fishing grounds of the Hawaii-based swordfish fishery. This new information was used to expand the TurtleWatch product to provide managers and industry near real-time habitat information for both loggerheads and leatherbacks. The updated TurtleWatch product provides





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a tool for dynamic management of the Hawaii-based shallow-set fishery to aid in the bycatch reduction of both species. Updating the management strategy to dynamically adapt to shifts in multi-species habitat use through time is a step towards an ecosystem-based approach to fisheries management in pelagic ecosystems.

Expected publication date: Spring 2015

The world's most isolated and distinct whale population? Humpback whales of the Arabian Sea
PLOS ONE (3.534)

C. Pomilla, A. R. Amaral, T. Collins, G. Minton, K. Findlay, **M. S. Leslie (NMFS/SWFSC)**, L. Ponnampalam, R. Baldwin, and H. Rosenbaum

- Genetic evidence suggests that humpback whales in the North Arabian Sea are highly distinct and have been isolated from other Indian Ocean populations for approximately 70,000 years.
- Our findings suggest this is the world's most isolated humpback whale population, which, when combined with low population abundance estimates and anthropogenic threats, raises concern for its survival.
- We recommend an amendment of the status of the population to Critically Endangered on the IUCN Red List.

A clear understanding of population structure is essential for assessing conservation status and implementing management strategies. A small, non-migratory population of humpback whales in the Arabian Sea is classified as “Endangered” on the IUCN Red List of Threatened Species, an assessment constrained by a lack of data, including limited understanding of its relationship to other populations. We analyzed 11 microsatellite markers and mitochondrial DNA sequences extracted from 67 Arabian Sea humpback whale tissue samples and compared them to equivalent datasets from the Southern Hemisphere and North Pacific. Results show that the Arabian Sea population is highly distinct; estimates of gene flow and divergence times suggest a Southern Indian Ocean origin but indicate that it has been isolated for approximately 70,000 years, remarkable for a species that is typically highly migratory. Genetic diversity values are significantly lower than those obtained for Southern Hemisphere populations and signatures of





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ancient and recent genetic bottlenecks were identified. Our findings suggest this is the world's most isolated humpback whale population, which, when combined with low population abundance estimates and anthropogenic threats, raises concern for its survival. We recommend an amendment of the status of the population to Critically Endangered on the IUCN Red List. Expected publication date: Late 2014/Early 2015

Assessing the ecological importance of red tree coral thickets in the eastern Gulf of Alaska
ICES Journal of Marine Science (2.525)

R. P. Stone, M. M. Masuda, and J. F. Karinen (NMFS/AKFSC)

- Red tree coral thickets are a dominant benthic habitat feature in the Gulf of Alaska (GOA), yet little is known about the ecosystems they support.
- The corals and sponges in the study areas provide essential fish habitat for some fish species, and larger corals and sponges are the most vulnerable to disturbance from bottom longline fishing practices.
- Modifications to longline gear and an expanded network of HAPCs could help preserve these keystone species and the ecosystems they support.

Red tree corals (*Primnoa pacifica*), the largest structure-forming gorgonians in the North Pacific Ocean, form dense thickets in some areas. In 2005, the authors used a submersible to study the ecology of thickets inside or near five small areas of the eastern GOA later designated in 2006 as Habitat Areas of Particular Concern (HAPCs) - areas closed to all bottom contact fishing. They showed that red tree corals are keystone species in habitats where they form thickets (mean density 0.52 corals/m²) - the densest and largest thickets documented anywhere. Measured sponge densities (2.51 sponges/m²) were also among the highest documented anywhere. The corals and sponges in the study areas provide essential fish habitat for some fish species, and their findings show with logistic regression models modified with a scaled binomial variance that bedrock, while important habitat for some fish, is even more important when paired with corals and sponges. Red tree corals were not equally distributed with regard to habitat characteristics, and their presence was correlated with bedrock substrate, moderate to high seafloor roughness, and slope greater than 10°. Most corals and sponges are vulnerable to





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disturbance from longlining, the principal bottom contact fishing in this region, but the larger corals and sponges are the most vulnerable. The authors observed evidence of infrequent recruitment events and a strong pulse of predation, apparently from fishing gear-induced trauma, that could exacerbate slow recovery of red tree corals from disturbance. Some red tree coral thickets are provided protection within designated HAPCs and some are not.

Modifications to longline gear and an expanded network of HAPCs could help preserve these keystone species and the ecosystems they support.

Expected publication date: 1 December 2014

Demographic clusters identified within the northern Gulf of Mexico common bottlenose dolphin (Tursiops truncatus) unusual mortality event: January 2010 - June 2013

PLOS ONE (3.534)

S. Venn-Watson, **L. Garrison (NMFS/SEFSC)**, **J. Litz (NMFS/SEFSC)**, **E. Fougères (NMFS/SERO)**, **B. Mase (NMFS/SEFSC)**, **G. Rappucci (NMFS/SEFSC)**, **E. Stratton (NMFS/SEFSC)**, R. Carmichael, D. Odell, D. Shannon, S. Shippee, S. Smith, L. Staggs, M. Tumlin, H. Whitehead and **T. Rowles (NMFS/OPR)**

- This paper identifies multiple demographic clusters of bottlenose dolphin strandings within the current ongoing unusual mortality event (UME) in the Gulf of Mexico, which can help target the investigation into causes of the observed mortality.
- The clusters identified include northern coastal Louisiana and Mississippi (March – May 2010), Barataria Bay, Louisiana (Aug. 2010 – Dec. 2011) and Mississippi and Alabama (2011, including a high prevalence and number of stranded perinates).
- The longest temporal cluster in this study was in Barataria Bay, Louisiana (Aug 2010 – Dec 2011). The timing and location of this cluster is consistent with the spatial and temporal distribution of oil in that area following the DWH spill.

A multi-year unusual mortality event (UME) involving primarily common bottlenose dolphins (*Tursiops truncatus*) was declared in the northern Gulf of Mexico (GoM) with an initial start date of February 2010 and remains ongoing as of August 2014. To examine potential changing characteristics of the UME over time, we compared the number and demographics of dolphin





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strandings from January 2010 through June 2013 across the entire GoM as well as against baseline (1990-2009) GoM stranding patterns. Years 2010 and 2011 had the highest annual number of stranded dolphins since Louisiana's record began, and 2011 was one of the years with the highest strandings for both Mississippi and Alabama. Statewide, annual numbers of stranded dolphins were not elevated for GoM coasts of Florida or Texas during the UME period. Demographic, spatial, and temporal clusters identified within this UME included increased strandings in northern coastal Louisiana and Mississippi (March-May 2010); Barataria Bay, Louisiana (August 2010-December 2011); Mississippi and Alabama (2011, including a high prevalence and number of stranded perinates); and multiple GoM states during early 2013. While the causes of the GoM UME have not been determined, the location and magnitude of dolphin strandings during and the year following the 2010 Deepwater Horizon oil spill, including the Barataria Bay cluster from August 2010 to December 2011, overlap in time and space with locations that received heavy and prolonged oiling. There are, however, multiple known causes of previous GoM dolphin UMEs, including brevetoxicosis and dolphin morbillivirus. Additionally, increased dolphin strandings occurred in northern Louisiana and Mississippi before the Deepwater Horizon oil spill. Identification of spatial, temporal, and demographic clusters within the UME suggest that this mortality event may involve different contributing factors varying by location, time, and bottlenose dolphin populations.

Accepted: November 2014

ADDITIONAL ARTICLES

NMFS PUBLICATIONS

Thermal potential for Steelhead life-history expression in a southern California alluvial river
Transactions of the American Fisheries Society (1.314)

D. A. Boughton (NMFS/SWFSC), L. R. Harrison (NMFS/SWFSC), A. S. Pike (UCSC & NMFS/SWFSC), J. L. Arriaza, and M. Mangel

- Bar-built estuaries are emphasized as key nursery habitat critical to recovery of steelhead populations on the south and central coast.





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- This study suggests that alluvial rivers, which are often highly impacted by human activities, appear to have the physical capacity to serve as similarly productive steelhead nursery habitat, even though they do not currently play that role.
- This finding suggests shifting the focus from abiotic to biotic elements such as alien species or feeding opportunities as key limiting factors in coastal alluvial rivers.

Steelhead (anadromous Rainbow Trout *Oncorhynchus mykiss*) near their southern range limit commonly use shallow alluvial rivers for migration, spawning and rearing. These rivers have been widely modified for water management, and an enduring question is whether their rehabilitation would create summer nursery habitat for Steelhead. The Authors used process-based models to evaluate the thermal potential for Steelhead nursery habitat in a regulated, alluvial river that currently supports few Steelhead. The Authors asked how well a calibrated model of river heat-fluxes predicts summer temperature patterns for a warm year and an average year; whether those patterns create thermal potential for rapid growth characteristic of nursery habitat; and whether manipulation of flows from an upstream dam significantly alters thermal potential. In the heat-flux model, the root mean square error (RMSE) for quarter-hour temperatures was 1.51 °C, about 3x greater than for a larger, deeper river in northern California. Generally, the river was thermally suitable but stressful for juvenile Steelhead. Augmenting flow reduced the number of thermally stressful days only near the dam, but reduced the intensity of thermal stress throughout the river. Daytime movement of Steelhead into natural thermally-stratified pools would reduce stress intensity by similar levels. In this region Steelhead commonly pursue anadromous life-histories by entering nursery habitat early in their first or second summer, and rapidly growing by fall to a threshold size for anadromy. In the average year, the river was thermally suitable for the first-summer path under high food availability and the second-summer pathway under medium food availability. The warm year also supported the second-summer path under high food availability. Currently the capacity of the river to support these pathways does not appear limited by summer temperature, indicating a need to identify other limiting factors.

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Long time series in U.S. fisheries oceanography

Oceanography (2.986)

S. McClatchie (NMFS/SWFSC), J. Duffy-Anderson (NMFS/AFSC), J. C. Field (NMFS/SWFSC), R. Goericke, D. Griffith (NMFS/SWFSC), D. S. Hanisko (NMFS/SEFSC), J. A. Hare (NMFS/NEFSC), J. Lyczkowski-Shultz (NMFS/SEFSC), W. T. Peterson (NMFS/NWFSC), W. Watson (NMFS/SEFSC), E. D. Weber (NMFS/SEFSC), and G. Zapfe (NMFS/SEFSC)

- The value of long time series fisheries oceanography surveys for fisheries management, research, ecosystem-based management, and for climate and environmental research is clearly demonstrated by the numerous applications described in this review.
- The scope of long time series and their value for science and management inevitably evolves from their original purpose.
- This review will help to clarify the value of these surveys to decision makers so that we can continue to collect time series that are fundamental for assessing long term changes in the oceans around the United States.

There are few fisheries oceanography surveys in the United States that have sampled hydrography and ichthyoplankton or juvenile fishes for 15 years or more. The Authors described six long time series surveys including three from the California Current System, and one from Alaska (Gulf of Alaska, Bering Sea and the Arctic), the Northeast U.S. Shelf, and the Gulf of Mexico. The Authors examined the applications of long time series data, and the output of published analyses, web-based graphical summaries, and quality controlled data to the broader scientific community (including resource managers and stakeholders). Potential improvements to the surveys using new technologies are evaluated, and possible changes in survey design are discussed. The Authors concluded with a summary of the benefits derived from these long time series fisheries oceanography surveys, and made the case for their continuation.

Accepted: 7 November 2014





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Inferring trackline detection probabilities ($g(0)$) for cetaceans from apparent densities in different survey conditions

Marine Mammal Science (1.82)

J. Barlow (NMFS/SWFSC)

- This study developed a method to estimate the relative values of $g(0)$, the probability of detecting an animal that is directly on the transect line, in different survey conditions.
- Results show that cetacean abundance is underestimated in rough sea conditions if the effect of Beaufort on the fraction seen is not considered.

Visual line-transect surveys are commonly used to estimate cetacean abundance. A key parameter in such studies is $g(0)$, the probability of detecting an animal that is directly on the transect line. This is typically considered to be constant for a species across survey conditions. The Authors developed a method to estimate the relative values of $g(0)$ in different survey conditions (Beaufort state) by comparing Beaufort-specific density estimates. The approach is based on fitting generalized additive models, with the presence of a sighting on a survey segment as the dependent variable, Beaufort state as the key explanatory variable, and year, latitude and longitude as nuisance variables to control for real differences in density over time and space. Values of relative $g(0)$ are estimated for 20 cetacean taxa using 175,000 km of line-transect survey data from the eastern and central Pacific Ocean from 1986-2010. Results show that $g(0)$ decreases as Beaufort state increases, even for visually conspicuous species. This effect is greatest for the least conspicuous species (rough-toothed dolphins, beaked whales, minke whales, and dwarf and pygmy sperm whales). Ignoring these large effects results in a nontrivial bias in cetacean abundance estimates.

Accepted: 14 October 2014

*Contrasting specialist and generalist patterns facilitate foraging niche partitioning in sympatric populations of *Pygoscelis penguins**

Marine Ecology Progress Series (2.64)

Michael J. Polito, **W. Z. Trivelpiece**, Patterson, Nina J. Karnovsky, **C. S. Reiss**, Steven D. Emslie (NMFS/SWFSC)





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- This study examines feeding patterns and niche partitioning among two species of Antarctic penguins.
- The narrower foraging niche observed in declining chinstrap penguin populations indicates they are likely highly sensitive to declines in the abundance of Antarctic krill.
- In contrast, the generalist niche exhibited by recently expanding gentoo penguin populations are likely better suited to the rapidly changing environmental conditions in the Antarctic Peninsula.

Specialization is a common mechanism of niche differentiation which can lead to ecological co-existence among species. However, species with specialized habitat or dietary requirements often exhibit a high degree of sensitivity to environmental change. Therefore, understanding patterns of specialization and niche segregation among Antarctic marine predators is of increased importance due to recent climate-driven reductions in a key prey species, Antarctic krill (*Euphausia superba*). We examined the stomach contents and stable isotope values of sympatric chinstrap (*Pygoscelia antarctica*) and gentoo penguins (*P. papua*) across five breeding seasons at Cape Shirreff, Livingston Island, Antarctica. Our goal was to examine foraging niche segregation and the degree of specialization between species during the chick-rearing period. Dietary and isotopic foraging niches indicated consistent niche partitioning with higher krill consumption and greater use of offshore foraging habitats by chinstrap relative to gentoo penguins. While chinstrap penguin diets were dominated by krill with little variation, gentoo penguins exhibited broader dietary and isotopic niches with a higher degree of variation. There was little evidence that shifts in the availability of adult krill influenced penguin diets or foraging niches during our study, though the contrasting foraging strategies identified provide insight into the differing population trends observed between penguin species. The narrower foraging niche observed in declining chinstrap penguin populations indicates they are likely highly sensitive to declines in the abundance of Antarctic krill. In contrast, the generalist niche exhibited by recently expanding gentoo penguin populations are likely better suited to the rapidly changing environmental conditions in the Antarctic Peninsula.

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*Low frequency vocalisations of sei whales (*Balaenoptera borealis*) in the Southern Ocean*

Journal Acoustical Society, Electronic Letters (1.65)

S. Calderan, B. Miller, **J. Barlow** (NMFS/SWFSC), K. Collins, P. Ensor, R. Leaper, and M. Double

- This is the first paper showing that sei whales in the Southern Ocean produce very low frequency calls (< 100 Hz).
- Knowledge that these calls are made by sei whales will aid in using passive acoustic monitoring tools to study the distribution and relative abundance of sei whales.

Simultaneous sightings and acoustic detections of sei whales (*Balaenoptera borealis*) are scarce, and there are few published data describing their vocalisations. Analysis of recordings from DIFAR sonobuoys in the presence of sei whales in the Southern Ocean in March 2013 identified both downsweep and upsweep calls. Sound frequencies within all calls were between 34 and 87 Hz, with an average call duration of 1.1 s. These very low-frequency sounds share characteristics with sei whale calls recorded near the Hawaiian Islands and off Cape Cod in winter and summer respectively, but are the first documented sei whale calls in the Southern Ocean that are clearly less than 100 Hz.

Expected publication date: February 2015

Data availability for Red Snapper in Gulf of Mexico and southeastern U.S. Atlantic Ocean waters

North American Journal of Fisheries Management (1.18)

R. Rindone (NMFS/OSF), **G. T. Kellison** (NMFS/SEFSC), and S. Bortone

- Relative to the Gulf of Mexico, there is limited information on Red Snapper life-history, ecology and fisheries interactions in southeastern US Atlantic Ocean waters.
- There is a particular dearth of information on the occurrence and distribution of early juvenile Red Snapper.
- Results highlight the need for additional information on Red Snapper in southeastern U.S. Atlantic Ocean waters, and on connectivity between Gulf of Mexico and southeastern





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U.S. Atlantic Ocean Red Snapper populations, to support Red Snapper population assessment and fishery management.

Red Snapper (*Lutjanus campechanus*) populations support (or have supported) important commercial and recreational fisheries in Gulf of Mexico and southeastern U.S. Atlantic Ocean waters. Stock assessment results and related regulatory actions are contentious in both regions. The authors assessed the relative availability of information to support Red Snapper assessment and management between the two regions by performing a literature review and comparing the number of region-specific, Red Snapper-focused peer-reviewed publications. One hundred and ten publications (published from years 1982-2013) were identified from this search, with 94% regionally focused in Gulf of Mexico waters. Twenty-eight peer-reviewed publications focused entirely or partially on juvenile Red Snapper (< 150 mm total length) in Gulf of Mexico waters. No publications or reports were identified which documented the occurrence of juvenile Red Snapper in southeastern U.S. Atlantic Ocean waters. For the Gulf of Mexico, more than 50,000 records of juvenile Red Snapper were identified in a single trawl survey database. For southeastern U.S. Atlantic Ocean waters, a comprehensive search of fishery-independent survey databases (totaling >75,000 individual gear deployments and occurring across the range of habitats, depths and seasons in which juvenile Red Snapper were collected in the Gulf of Mexico trawl survey) and institutional collections identified only 132 records of juvenile Red Snapper. These results highlight the need for additional information on Red Snapper in southeastern U.S. Atlantic Ocean waters, and on connectivity between Gulf of Mexico and southeastern U.S. Atlantic Ocean Red Snapper populations, to support Red Snapper population assessment and fishery management

Accepted: 13 November 2014

NOS PUBLICATIONS

Assessing cold-snap and mortality events in south Florida coastal ecosystems: development of a biological cold stress index using satellite SST and weather pattern forcing

Estuaries and Coasts (2.245)

D. E. Pirhalla, S. C. Sheridan, V. Ransibrahmanakul, and C. C. Lee (NOS/NCCOS)





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- Characteristics of sea surface temperature as a lethal response indicator are defined, whereby persistence of specific weather patterns can act to reinforce a negative behavioral or physiological response on habitats, species and populations.
- Synoptic weather patterns appear to be temporally linked to cold-snap frequency, duration, and magnitude of events along the entire study area.

Water temperature is considered both a controlling and lethal factor in coastal ecosystems, influencing behavioral and physiological responses in marine organisms. Abrupt weather events such as severe cold front passages and accompanied changes in weather conditions have led to sharp decreases in water temperatures, metabolic stress and incidences of mortality in marine organisms. In this paper, we assess the weather-related factors associated with physical and biological response in South Florida systems through historical sea surface temperature (SST) from satellites and the use of a synoptic climatology spanning over 30 years. We utilize previous categorizations of sea-level pressure and newly developed categorizations of 850-millibar temperature reanalysis data to define circulation and temperature patterns across the southeastern US and adjacent Gulf of Mexico. Systematic connections are seen between particular circulation and temperature patterns characteristic of enhanced north-to-south circulation and cold air outbreaks, SST, and turtle strandings data over the Florida Panhandle region for the period 2006-2013. Identified weather forcing variables associated with sharp SST decreases and turtle stuns are presented and assist in the formulation of a moving cold- stress index (CSI) for South Florida coastal ecosystems. Results demonstrate the potential of using synoptic climatological analysis and derived indices for tracking and modeling changes in SST and other indicators related to biological health.

Accepted: 13 November 2014

NESDIS Publications

Temporal changes in surface partial pressure of carbon dioxide and carbonate saturation state in the eastern equatorial Indian Ocean during the 1962–2012 period

Xue, L., W. Yu, H. Wang, **L.-Q. Jiang** (NESDIS/NODC), L. Feng, L. Gao, K. Li, Z. Li, Q. Wei, and C. Ning





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Biogeosciences (4.193)

- This study improved the understanding of the temporal changes of the inorganic carbon system, and ocean acidification in the Indian Ocean, demonstrating that big changes in carbon chemistry (e.g., OA) and other marine biogeochemical processes have taken place in the Indian Ocean since 1960s.
- Despite being a source of carbon dioxide to the atmosphere, surface water pH (total hydrogen scale) and saturation state for aragonite in the eastern equatorial Indian Ocean, decreased significantly at rates of -0.0016 and -0.0095 yr⁻¹ from 1962 to 2012, respectively.
- The increase in dissolved inorganic carbon was most likely associated with the increasing atmospheric carbon dioxide (CO₂) concentration and the consequent decrease of CO₂ to the atmosphere, and the transport of accumulated anthropogenic CO₂ from a CO₂ sink region via basin-scale ocean circulations.

Information on changes in the oceanic carbon dioxide (CO₂) concentration, air-sea CO₂ flux, as well as ocean acidification in the Indian Ocean is very limited. In this study, the temporal changes of the inorganic carbon system in the eastern equatorial Indian Ocean (EIO, 5°N to 5°S along 90°E and 95°E) are examined using the partial pressure of carbon dioxide (pCO₂) data collected in May 2012, historical pCO₂ data since 1962, and total alkalinity (TA) data calculated from salinity. Results show that sea surface pCO₂ in the investigated area increased from ~304 μ atm in April 1963 to ~374 μ atm in May 1999, ~384 μ atm in April 2007, and ~394 μ atm in May 2012. The mean rate of pCO₂ increase in this area (~1.69 μ atm yr⁻¹) was close to that in the atmosphere (~1.46 μ atm yr⁻¹). Despite the steady pCO₂ increase in this region, no significant change in air-sea CO₂ fluxes was detected during this period. Ocean acidification as indicated by pH and saturation states for carbonate minerals, has indeed taken place in this region. Surface water pH (total hydrogen scale) and saturation state for aragonite (Ω_{arag}), as calculated from pCO₂ and TA, decreased significantly at rates of -0.00168 ± 0.0001 yr⁻¹ and -0.010 ± 0.001 yr⁻¹, respectively. The respective contributions of temperature, salinity, TA, and dissolved inorganic carbon (DIC) to the increase in surface pCO₂ and the decreases in pH and Ω_{arag} are quantified. We find that the increase in DIC dominated these changes, while





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contributions from temperature, salinity and TA were relatively insignificant. The increase in DIC was most likely associated with the increasing atmospheric CO₂ concentrations, and the transport of accumulated anthropogenic CO₂ from a CO₂ sink region via basin-scale ocean circulations. These two processes may combine to drive oceanic DIC to follow atmospheric CO₂ increase.

Publication date: 21 November 2014

OTHER REPORTS, BOOK CHAPTERS, AND INTERNAL PUBLICATIONS

Economic impact of recreational fishing in California National Marine Sanctuaries on local area economies 2010, 2011, and 2012

Six Office of National Marine Sanctuaries (ONMS) Conservation Science reports.

- Recreational fishing activity within sanctuary boundaries was estimated annually for 2004 through 2012.
- Spending and the associated economic impacts on output, value-added, income and employment of local area economies were estimated for three years (2010, 2011 and 2012) plus the 3-year average.

NOAA's Office of National Marine Sanctuary (ONMS) economists have developed six reports (one report for each of the four CA sanctuaries – Channel Islands, Cordell Bank, Gulf of the Farallones, and Monterey Bay, a summary report across the four sanctuaries and a technical appendix detailing estimation methods) on the economic impact on local area economies from recreational fishing activity in each sanctuary. Citations for the reports are as follows:

V. R. Leeworthy and D. Schwarzmann (NOS/ONMS). 2014. Economic Impact of the Recreational Fisheries on the California Economy in California's National Marine Sanctuaries, 2010, 2011 and 2012. Marine Sanctuaries Conservation Series ONMS. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Office of National Marine Sanctuaries, Silver Spring, MD.

V. R. Leeworthy and D. Schwarzmann (NOS/ONMS). 2014. Economic Impact of the Recreational Fisheries on Local County Economies in Channel Islands National Marine





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Sanctuary, 2010, 2011 and 2012. Marine Sanctuaries Conservation Series ONMS. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Office of National Marine Sanctuaries, Silver Spring, MD.

V. R. Leeworthy and D. Schwarzmann (NOS/ONMS). 2014. Economic Impact of the Recreational Fisheries on Local County Economies in Cordell Bank National Marine Sanctuary, 2010, 2011 and 2012. Marine Sanctuaries Conservation Series ONMS. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Office of National Marine Sanctuaries, Silver Spring, MD.

V. R. Leeworthy and D. Schwarzmann (NOS/ONMS). 2014. Economic Impact of the Recreational Fisheries on Local County Economies in Gulf of the Farallones National Marine Sanctuary, 2010, 2011 and 2012. Marine Sanctuaries Conservation Series ONMS. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Office of National Marine Sanctuaries, Silver Spring, MD.

V. R. Leeworthy and D. Schwarzmann (NOS/ONMS). 2014. Economic Impact of the Recreational Fisheries on Local County Economies in Monterey Bay National Marine Sanctuary, 2010, 2011 and 2012. Marine Sanctuaries Conservation Series ONMS. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Office of National Marine Sanctuaries, Silver Spring, MD.

C. Chen (NOS/OCS), V. R. Leeworthy (NOS/ONMS), and D. Schwarzmann (NOS/ONMS). 2015. Technical Appendix: Economic Impact of the Recreational Fisheries on Local County Economies in California National Marine Sanctuary 2010, 2011 and 2012. Marine Sanctuaries Conservation Series ONMS. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Office of National Marine Sanctuaries, Silver Spring, MD.

Expected publication date: January 2015

